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# Land reclamation and improvement works using a nature-based approach

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**Abstract: Land reclamation and improvement works are a significant part of agricultural water management and have influences spread in all components of land-water-climate-energy nexus. They provide important ecosystem services including groundwater recharge, flood retention, carbon sequestration, erosion control, accumulation of soil organic matter, recycling of soil nutrients, supporting diversity by providing habitats for flora and fauna.**

**The growing concern for environment imposes the necessity to identify nature-based approaches for different land reclamation and improvement works. Ecosystem services provided by land reclamation and improvement works may represent a sustainable solution in achieving the aimed objectives without compromising the environmental aspects.**

**In this paper will be identified and discussed several natural-based approaches used in land reclamation and improvement works.**

**This paper is based on the outcomes results from the bilateral project "Ecological solutions for reducing hydro-meteorological risks and climate change adaptation", project carried out by "Research within Priority Sectors" Program financed by EEA Grants**

**Keywords: nature-based approach, land reclamation and improvement, ecosystem services**

## 1. INTRODUCTION ON LAND RECLAMATION AND IMPROVEMENT WORKS

Agricultural lands and agricultural production are threatened by climate changes especially due to the severe changes in rainfall and temperatures variability. The increasing pressure on lands and agricultural water management stemming from complex water-food-energy linkages requires an improved integrated land and water resources management [1].

Water scarcity and water excess (water logging) have a negative impact on agricultural productions and can be managed with the help of land reclamation and improvement arrangements: irrigation, surface drainage, deep drainage, soil erosion control etc. These technical options have often been considered as adaptation strategies [2].

Ecology dictionary gives the following definition for land reclamation: the concept of land reclamation means "making land capable of more intensive use by changing its general character, as by drainage of excessively wet land; irrigation of arid or semiarid land; or recovery of submerged land from seas, lakes and rivers".

Land reclamation counteracts a specific form of land degradation while land improvement refers to increasing the land value and its productive capacity. Land reclamation and improvement works includes mainly irrigation and drainage systems but also soil erosion control works. Land reclamation and improvement arrangements are managing land, water and plants, are both energy users and providers, have a strong impact on land management and are answering to climate changes by mitigating their effects and by creating microclimates.

Land reclamation and improvement works are a significant part of agricultural water management and have influences spread in all components of land-water-climate-energy nexus. They provide important ecosystems services including groundwater recharge, flood retention, carbon sequestration, erosion control, accumulation of soil organic matter, recycling of soil nutrients, supporting diversity by providing habitats for flora and fauna. Integrating these different benefits in the framework of agricultural water management requires breaking down disciplinary boundaries between engineers, ecologists, agronomists, economists, hydrologists and climate scientist and the appliance of some reliable climate-energy-economic models as well as land-use models.

The integration of land reclamation works in sustainable land management represents a new scientific approach especially regarding the problem from the point of view of ecosystem services provided by these works. This type of approach will overrun the interdisciplinary borders and will assume a stronger cooperation from planning to implementation.

## 2. ECOSYSTEM SERVICES PROVIDED BY LAND RECLAMATION AND IMPROVEMENT WORKS

The Millennium Ecosystem Assessment report from 2005 defines the ecosystem services as being the benefits which people obtain from ecosystems and distinguishes four categories of ecosystem services (supporting services, provisioning services, regulating

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services and cultural services), where the so-called supporting services are regarded as the basis for the services of the other three categories [3].

Land reclamation and improvement arrangements, especially irrigation and drainage works, possess the capabilities to provide important ecosystem services mainly from the first three categories: supporting, provisioning and regulating services. The main potential supporting ecosystem services are including soil erosion control, soil nutrients recycling and soil organic matter accumulation.

Land reclamation and improvement works like irrigation and drainage are focused mainly on increasing food production and have the potential to provide important ecosystem services. Moreover, these works also generate a series of provisioning, regulating and supporting services including here groundwater recharge, flood and sediment retention, carbon sequestration, erosion control, accumulation of SOM, recycling of soil nutrients, supporting species diversity etc.

The lack of implementing sustainable land management measures is an important impediment in gaining these services.

Sustainable land management is defined as the use of land and water resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions. The tillage reduction in combination with land covers restoration and the maintenance of water in soil are only a few parts of an efficient and sustainable land management will have a positive impact on increasing agricultural productivity and will also deliver important services like reducing the erosion [4].

## 3. NATURE-BASED APPROACH IN LAND RECLAMATION AND IMPROVEMENT WORKS – THEORETICAL ASPECTS

After decades of neglect, the importance of protecting and improving ecosystems for reducing disaster risk started to receive attention in the recent years [5].

An EU agenda on NbS will enable Europe to become a world leader in the growing market for NbS [6]. For this, the evidence base for the effectiveness of NbS needs to be developed and then used to implement them.

There is international acknowledgement that efforts to reduce disaster risks must be systematically integrated into policies, plans and programmes for sustainable development, economic development and poverty reduction, and supported through bilateral, regional and international cooperation, including partnerships [7].

Nature-based solutions aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. The "nature-based solution" concept builds on and supports other closely related concepts, such as the ecosystem approach, ecosystem services, ecosystem-based adaptation/mitigation, and green and blue infrastructure. They all recognize the importance of nature and require a systemic approach to environmental change based on an understanding of the structure and functioning of ecosystems, including human actions and their consequences.

The concept of nature-based solutions (NbS) is one of several concepts that promote the maintenance, enhancement, and restoration of biodiversity and ecosystems as a means to address multiple concerns, like hydro-meteorological risks, simultaneously. Nature-based solutions can be characterized as "[...] the use of nature in tackling challenges such as climate change, food security, water resources, or disaster risk management, encompassing a wider definition of how to conserve and use biodiversity in a sustainable manner" [8].

Ecosystem-based adaptation (EBA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change. EBA aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change.

The ecosystem-based approach has been recognized as an important strategy for disaster-risk reduction (Eco-DRR) aims to achieve sustainable and resilient development through a sustainable management, conservation and restoration of ecosystems to reduce disaster risk [9].

A key challenge is to systematically collate and critically review the evidence from existing NbS projects aiming at reducing hydro-meteorological hazards; and assessing the relevance, completeness, comprehensiveness and quality of this evidence. Once a robust proof-of-concept has been established for several key hydro-meteorological hazards, it needs to be further tested in other social-ecological settings.

A wide range of evidence is required in order to assess the effectiveness of each NbS under scrutiny, including the bio-physical and economic aspects, as well as the social and behavioural changes required in order for them to be understood, accepted, implemented, and sustainably managed.

The spatial extend required for NbS to be effective means that a strong element of participatory methods needs to be included so that all the relevant stakeholders are both included and fully involved in the development of the proof-of-concept and the implementation of NbS approaches [9].

## 4. NATURE-BASED APPROACH IN LAND RECLAMATION AND IMPROVEMENT WORKS – PRACTICAL ASPECTS

The actual methodology in designing land reclamation works has an economic approach: reducing the effects/ removing the stress factors for maintaining/ increasing agricultural production at low costs. Unfortunately, many key issues as the potential impact on environment, adaptation to climatic variability, soil and water conservation aspects, climate change manipulation techniques using these works, are not considered.

Some studies were dedicated to analysing relevant factors as changes in agricultural demand, competition over land and water resources for other uses, availability and cost of new agricultural technologies in terms of new water and energy sources. Even there exists a significant knowledge of new water harvesting techniques as well as on different types of energy sources, these advancements were not significantly integrated so far in land reclamation and improvement policies, leaving this sector under environmental, economic and social pressures generated by lack of fresh water sources, high cost of energy, high demands for land etc.

Challenges within rainfed farming are many in arid, semiarid, sub-humid and even in humid regions. Water for production continues to be a key constraint to agriculture, due to highly variable rainfall, long dry seasons, and recurrent droughts, as well as floods. If rainfall is less than crop water requirements, then clearly actual yields will be less than the potential; moreover the impact of variable rainfall is strongly affected by the nature of the soil and the stage of the growing period [10].

In areas with low and insecure rainfall, irrigation continues to play an important role in increasing crop production and food supply. However, large irrigation schemes have proved to be controversial due to problems of high costs, mismanagement, damaged ecosystems, limited water resources, salinization, over-abstraction and increasing conflicts over scarce water. Often, a more viable alternative for small-scale production is supplementary irrigation, which complements precipitation during periods of water deficit or stress at sensitive stages of plant growth. There are many technologies that help supply water for supplementary irrigation. These range from dams collecting water for large-scale water supply and irrigation, to farm ponds and shallow wells from which water can be extracted with treadle (or other) pumps for micro-irrigation [11].

Water harvesting (WH) has been defined and classified in a number of ways by various authors over the years. The large majority of definitions are closely related, the main difference being how broad the scope is: in other words what is included and what is left out.

The aim of water harvesting is to collect runoff or groundwater from areas of surplus or where it is not used, store it and make it available, where and when there is water shortage.

This results in an increase in water availability by either (a) impeding and trapping surface runoff, and (b) maximising water runoff storage or (c) trapping and harvesting sub-surface water (groundwater harvesting). Water harvesting makes more water available for domestic, livestock and agricultural use by buffering and bridging drought spells and dry seasons through storage [11].

Water harvesting must be seen as an integral part of sustainable land (and water) management.

The basic principle of water harvesting is to capture precipitation falling in one area and transfer it to another, thereby increasing the amount of water available in the latter.

The basic components of a water harvesting system are a catchment or collection area, the runoff conveyance system, a storage component and an application area. In some cases the components are adjacent to each other, in other cases they are connected by a conveyance system. The storage and application areas may also be the same, typically where water is concentrated in the soil for direct use by plants [11].

• Catchment or collection area: this is where rain in the form of runoff is harvested. The catchment may be as small as a few square meters or as large as several square kilometres. It may be a rooftop, a paved road, compacted surfaces, rocky areas or open rangelands, cultivated or uncultivated land and natural slopes.

• Conveyance system: this is where runoff is conveyed through gutters, pipes (in case of rooftop WH) or overland, rill, gully or channel flow and either diverted onto cultivated fields (where water is stored in the soil) or into specifically designed storage facilities.

• Storage component: this is where harvested runoff water is stored until it is used by people, animals or plants. Water may be stored in the soil profile as soil moisture, or above ground (jars, ponds or reservoirs), or underground (cisterns) or as groundwater (near-surface aquifers) [12]. There, where concentrated runoff is directly diverted to fields, the application area is identical to the storage area, as plants can directly use the accumulated soil water. A great variety of designed storage systems keep the water until it is used either adjacent to the storage facilities or further away.

• Application area or target: this is where the harvested water is put into use either for domestic consumption (drinking and other household uses), for livestock consumption, or agricultural use (including supplementary irrigation).

End users manage water according to different strategies and principles, depending on the amount of rainfall, potential evapotranspiration and the cropping system (or other use of water). Four different water management strategies can be recognised [11, 13]:

1. Management of excess water from rainfall or seasonal flooding through controlled drainage and water storage for future use. Most suitable in humid and sub-humid conditions as well as semi-arid and arid conditions (floodwater harvesting).

2. Increasing rainwater capture and availability, making use of surface runoff; suitable for dry sub-humid to arid conditions (rainwater harvesting).

3. Reducing *in situ* water loss: improving direct water infiltration and reducing evaporation; soil water conservation practices that prevent surface runoff and keep rainwater in place (e.g. conservation agriculture, level bench terraces, mulching, dew harvesting); suitable for sub-humid to semi-arid conditions (*in situ* water conservation).

4. Increasing water use efficiency (e.g. good agronomic practice, including use of best-suited planting material and fertility management).

Water harvesting technologies recommended for upscaling must be profitable for users and local communities, and technologies must be as simple and inexpensive as possible and easily manageable also. Without security of land tenure, water rights and access to markets, land users remain reluctant to invest labour and finances in WH. Cost efficiency, including short and long-term benefits, is another key issue in the adoption of WH practices. Resource users are naturally more willing to adopt practices that provide rapid and sustained pay-back in terms of water, food or income [11].

Water harvesting can be planned and implemented at different scales; from isolated individual plots within fields up to schemes covering a whole watershed or landscape. This has implications for the involvement of land and water users and their right to use their own or communal land and water, and to implement water harvesting structures on their own or on community public land. As long as individuals have access and rights over land and water, they can decide and implement according to their will and the resources available. They may need external support, expertise and training in order to implement WH. This typically applies to rooftop and courtyard WH as well as to microcatchment or in-field WH. For implementation of WH at a larger scale, community mobilisation and involvement is indispensable. There is a fundamental difference between WH interventions based on individual 'autonomy' and those that need community involvement: the latter require different approaches and the attention of implementing agencies. There are potential problems with conflict for 'runoff rights' and impacts on downstream water users. Furthermore larger-scale projects and structures can be difficult to implement as they need acceptance by the majority of land users, political backing and greater financial support [11, 14].

Current mainstream water resource management (WRM) schools do not sufficiently take WH or its multiple-use water services into consideration – the "blue water agenda" (i.e. irrigation) is more powerful than the "green water agenda" (i.e. rainfed farming). Both are important but green water management needs greater attention.

## 5. CONCLUSIONS

With increasing population, climate change, higher food prices and growing shortages of safe drinking water, increasing emphasis must be put on nature-based approaches for land reclamation and improvement works. Water harvesting in particular has high potential: not only for increasing crop production in dry areas, but also in providing drinking, sanitation and household water as well as water for livestock. However, initiatives are still too scattered, and experiences related to "best" WH practices are poorly shared. Policies, legal regulation and governmental budgets often lack the inclusion of water harvesting in integrated water resource management and poverty reduction strategies.


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